# Materials for IML: What to Use and Why?

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# MATERIALS FOR IML: WHAT TO USE AND WHY?


## ABSTRACT

*This is a brief review of some material choices for IML and how the choices influence the performance of labels and containers.*


## INTRODUCTION

Material choices for an in-mold label include substrate, adhesive, inks, and overprint coatings. What material to use for each element of an in-mold label cannot be considered in isolation but must be evaluated for its contribution to the complete label and its influence on the IML process. Consider first the label substrate.

## FILM VS. PAPER LABELS

The ideal or fantasy in-mold label would be a film that prints and handles like paper, requires no heat seal coating, and is half the price of paper. Until we reach that lofty goal, we must deal with the realities of what we do have available in film label substrates. Actually, currently available labeling films and those under development have much to offer compared with paper. Here are some advantages that film in-mold labels have over paper.

### Regrindable Offware

Polyolefin-based film in-mold labeled containers can be re-ground and fed back into the extruder for reprocessing.

### Post-Consumer Recycling

Film in-mold labeled containers would not be considered co-mingled material and after classification could be fed directly to a HDPE recycler.

### "No Label" Look

A clear or contact clear, reverse or surface printed film in-mold label provides a "no label" look.

### Moisture and Product Resistance

Film in-mold labels provide superior resistance to moisture and product spills. This is a real advantage for containers used for refrigerated beverages and household chemicals.

### Hot Fill Resistance

Plastic labels have an advantage in hot filled food packaging where paper labels have shown poor resistance to heating and water cooling cycles.

**Improved Heat Transfer**

Because the film label and polyolefin bottle have similar heat transfer properties, label bulge and other stresses on the label seen with paper labels are mostly eliminated. Cool down after blow molding is faster, and label failures are reduced.

**Smaller Containers**

Elimination of de-labeling makes smaller bottles more economical to produce.

Some real disadvantages must still be overcome in film in-mold labels compared with paper.

**Die Cutting**

The same thermoplastic properties that make film labels attractive can also cause edge welding when they are stacked and die cut. In-line or off-line rotary die cutting or off-line flatbed die cutting can prevent edge welding.

**Multiple Feeding**

Film labels have a greater tendency to multiple feed out of the label magazines than do paper labels. Film labels are more subject to static problems and blocking and have poorer stiffness than paper.

**Dimensional Stability**

Many film labels, especially those printed on oriented films, will become distorted when exposed to heat during printing, heat seal coating, or blow molding.

**Cost**

By far the greatest disadvantage of film labels is their cost. This is still 1.5–2 times that of paper.

## PAPER SUBSTRATES

The base paper used for the production of in-mold labels is not very different from that used to make conventional glue applied labels with certain important exceptions. Lay flat and curl characteristics must be more carefully controlled for the in-mold process. This is very important for trouble-free feeding of labels from the magazines. Labels that have excessive curl tendencies create multiple pick problems during the blow molding cycle.

The clay coating on a coated two-side sheet also plays a far more important function than in conventional label production. It prevents the wet coating from penetrating into the fibers of the paper. If this "hold out" coating is not smooth and uniform, the heat seal layer will be uneven resulting in label defects such as blistering and flagging. The pigment to binder ratio of the clay coating is also critical to in-mold label function. Inadequate binder can adversely affect moisture resistance and overall label adhesion.

Many label adhesion problems initially blamed on the heat seal have been traced to a failure in the clay coating.

Unfortunately, the in-mold label business although significant to those who work in it is a very small market for the paper suppliers. Very few suppliers have been willing to custom design a base sheet for in-mold labeling and provide the kind of quality control to prevent the sort of recurring problems seen over the past two decades.

## ADHESIVES

For extrusion blow molded IML, the heat seal coating on the back side of the label may well be the most critical functional component in the in-mold labeling process. The most widely used heat seal coatings for in-mold labeling are EVA-based either solvent or water borne. Water borne adhesives are especially useful for solvent-sensitive polyolefin label films. Many of the newer film substrates now available have an extrusion applied or co-extruded sealant layer rather than a liquid-applied heat seal coating.

Whatever the composition of the adhesive may be, it must have certain attributes for efficient application:

### Viscosity/Rheology

In its liquid form, the heat seal coating must have viscosity and rheology properties that will make it easily coatable on the available equipment at optimum line speeds, solids content, and coating weight.

### Pot Life

The liquid coating needs good stability under running conditions to minimize downtime and clean-up during multi-shift production runs.

### Ease of Drying

Once it is laid down, the wet coating must release its volatiles under the nominal drying conditions available at high press speeds. High levels of retained volatiles—solvent or water—can cause label blocking, blistering, or poor adhesion in the blow molding cycle.

### Resistance to Tacking

The dry heat seal coating should not become tacky as it passes over downstream idler rollers. This is particularly important in the printing and over-lacquering of pre-coated label stock. Careful use of chill rollers can help minimize premature activation of the heat seal coating.

## FUNCTIONAL CHARACTERISTICS OF HEAT SEAL COATINGS

The functional characteristics of the heat seal coating are critical to the proper performance of both paper and film in-mold labels.

### Surface Slip

The slip or coefficient of friction (COF) properties of the heat seal must be controlled so that the coated web or sheets will track through the label manufacturing process smoothly with a minimum of cling or static problems. This is particularly important in jogging sheets of labels during stacking operations before die cutting. Label slip properties are also critical to feeding of labels from the magazine to the mold cavities without double or triple picking. Dry slip powders commonly used to assist sheet handling should not be used in the manufacture of in-mold labels because these powders can interfere with heat seal adhesion and clog the vacuum port system.

### Non-Blocking

The blocking resistance of a heat seal coating is the combined function of its surface slip and activation temperature. The heat seal must have sufficient blocking resistance to permit storage of both pre-coated stock and finished labels in either roll or sheet form under a reasonable ambient temperature range. In addition to overall blocking, edge welding can occur during the die cutting operation if the coating is too soft, activates at too low a temperature, or has a high level of retained solvents. The latter act as plasticizers and soften the coating. Either of these forms of blocking can cause problems in feeding of labels from warm magazine stacks during the blow molding operation.

### Activation Temperature

The mechanics of in-mold label heat seal activation are quite different from that of conventional heat seal labels. A conventional, direct heat seal label is sealed to a substrate by the application of heat and pressure to the printed face of the label. The heat seal coating on the back side of the label becomes molten and wets the surface of the substrate. In the in-mold process, the heat seal is at or below ambient temperature until it is contacted by the hot molten plastic. The correct combination of plastic temperature, pressure, and dwell time is required for proper heat seal activation and satisfactory in-mold label performance. If one or more of these parameters are out of balance, label failure or sub-standard performance will result.

There is little latitude in the blow molding process to accommodate specific heat seal activation requirements. Temperature and pressure are largely determined by the plastic used and the geometry of the mold cavity itself. Dwell time in the mold cavity under pressure is dictated by required production rates. The heat seal must be designed with activation properties compatible with the blow molding conditions while also considering other temperature-related factors such as blocking resistance, set-up, and hot tack.

### Adhesion

The heat seal must be designed for specific adhesion to the type of plastic container to be labeled and to the label substrate itself. This can be quite challenging when dealing with

polypropylene films. Polyolefin bottles such as high-density polyethylene and polypropylene require a heat seal that is quite different from that used for PET bottles. Blow molding temperatures, container chemical composition, and mold release agents are but a few factors that influence heat seal formulation.

**Set-up Time**

When the still hot container is ejected from the mold, the residual heat in the container can re-activate the heat seal coating. The bond strength of the heat seal coating must be sufficiently high to prevent label separation from the container. This can be seen as edge lifting (flagging) or blistering. The heat seal property that resists these forces is known as its hot tack. Hot tack can be thought of as the bond strength of the molten adhesive immediately after the bond is formed. A certain amount of container shrinkage will occur during the cooling process. The amount of this contraction is a function of plastic composition, container configuration, and blow molding conditions. Shrinkage can cause label distortion such as crazing if the heat seal is not completely set.

**Heat Resistance**

Heat resistance differs from hot tack in that it is the temperature to which a cold bond can be raised before it fails. Heat resistance is important in maintaining label integrity during hot filling and container usage and during storage at elevated temperatures. It is a combined function of activation range and adhesion properties to the specific container composition.

**Product Resistance**

Since the label in the in-mold process becomes a flush, integral part of the container wall, potential exposure of the heat seal to the packaged product is generally minimal. For paper labels, satisfactory protection of label integrity and graphics is usually achieved by proper selection of the overprint lacquer or use of a non-wicking label stock. Special properties might be required in the in-mold label heat seal itself to resist attack by aggressive products such as paint thinner, automotive fluids, cooking oils, and pesticides. Film labels are ideal for applications where product resistance is a special requirement.

**Removability**

As in most manufacturing processes, misformed or mislabeled containers (offware) may occasionally be produced that must be recycled. Before paper in-mold labeled containers may be reprocessed, the labels must be removed to avoid contamination of the plastic regrind. Most blow molders have developed their own proprietary removal techniques. What little is known about these methods suggest that they take advantage of the heat activating properties of the label heat seal to soften the coating for removal. One attribute of film labels is their regrindability without the need for label removal.

**Regulatory Status**

End users frequently require the heat seal on in-mold labeled containers for home use products to exceed the requirements of appropriate federal regulations. For example,

while in-mold labels may be placed on the outside of non-food containers, the heat seal coatings often must comply with direct food contact FDA regulations.

## INKS AND OVERPRINT COATINGS

Although in-mold labels for blow molded IML are exposed to the high temperature of the parison for only a short time, it is advisable to use process inks that have better than average heat, chemical, and abrasion resistance. In-mold labeled bottles retain heat from the blow molding cycle for a long time especially when packed in cases and stored in hot warehouses. Heat resistant inks such as those used for heat sealable lidding applications are recommended. UV curable inks are becoming quite popular for IML applications because they provide superior physical properties and outstanding gloss. There are some concerns about the recyclability of UV cured ink and coatings, but test results thus far are inconclusive.

In-mold labels for injection molded containers are subjected to even higher temperatures and pressures during the injection process. Once ejected from the mold, a flat lid or open top tub will quickly cool to ambient temperature.

Since the labels on in-mold containers start life long before they are filled with product, the overprint lacquer must provide superior protection against abrasion and the heat of blow molding. Again, UV curable top lacquers are useful. In choosing an overprint coating, printers should be aware of the potential for blocking due to plasticizer migration from the top lacquer into the heat seal coating. This can take place in the master roll, during die cutting, or in the hot label magazines at the blow molding machine. Plasticizer migration has also been responsible for label adhesion failure or localized defects. Plasticizer in the heat seal coating will soften it and lower its activation and heat resistance temperatures. Consult a coating supplier and be certain he knows his lacquer will be used for an in-mold application.

## CONCLUSION

Each component of an in-mold label must perform its function in concert with the others to satisfy the rigorous requirements of the IML process.

# The IML Process: Why In-Mold Labeling

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## IN-MOLD LABELING VS. OTHER LABELING METHODS

In-mold labeling, post-mold paper and film labeling, silk screen direct printing, sleeve labeling, and heat transfer labeling are all capable of high quality graphics. The in-mold process offers some advantages not attainable with the others. Very large labels such as those on the two-gallon liquid laundry detergent bottles are easily done by the in-mold process. In-mold labeling also offers a gram weight savings that the others do not. The following table compares the features of in-mold labeling with heat transfer and pressure sensitive labeling.

| FEATURES | IN-MOLD LABELING | HEAT TRANSFER | PRESSURE SENSITIVE |
|---|---|---|---|
| Label Costs, per MSI | Less for Long Runs | More for Long Runs | More for Long Runs |
| Design Changes | Mold Change | Change Label Only | Change Label Only |
| Labeling Equipment | Cost for New Molds | Large Existing Base | Large Existing Base |
| Set-up Costs | High if New Molds | Low for New Label | Low for New Label |
| Finished Bottles | Less per 1,000 | More per 1,000 | More per 1,000 |
| Labeling Speed | Equal | Equal | Faster |
| Label Size | Very Large | Limited | Very Large |
| Container Material | Any | Any | Any |
| Flame Treatment | Not Required | Required | Required |
| "No Label" Look | Film Labels | Yes | Film Labels |
| Scrap Recycle | Film Labels | Yes | Film Labels |
| Full Rounds | Yes | Yes | Yes |
| Short Runs | Sl. More Expensive | Less Expensive | Less Expensive |
| Metallized Labels | Good on Films | Good | Very Good |
| Graphics Quality | Excellent | Good | Excellent |
| Release Liner | None | Must be Recycled | Must be Recycled |
| Extra Process | No | Yes | Yes |

## CONCLUSION

In-mold products can use extrusion blow molding, injection stretch blow molding, injection in-mold labeling, or thermoform in-mold labeling. Regardless of technique, the IML process offers advantages including faster packaging speeds, improved appearance, etc. Some disadvantages are long set-up time, need for long runs, etc. The potential user of IML must compare the process to other label techniques such as heat transfer labels and pressure sensitive adhesive labels.